Remarks

Claims 1-11 have been examined, claims 1-7, and 11 are rejected, and claims 8-9 are objected to, but allowable if rewritten in independent form.

The Examiner objected to the abstract of the disclosure. The abstract has been amended to overcome the objection.

The Examiner objected to claim 6 regarding the relative size and relationship of the rectangle and the polygon. The claim clearly states that the display area is enclosed by the polygon. That the display area is a rectangle, and that the rectangle is in fact a largest possible rectangle that can be enclosed by the polygon, see Figure 1, 135-136. However, to expedite the examination, claim 6 has been rephrased to make the relationship even more definite.

The Examiner objected to claim 8 regarding maximum likelihood estimation. Maximum likelihood estimation (MLE) has been well known in the art for a couple of centuries. The principles of MLE can be traced back to Pierre Laplace (1749-1827), also see Scott R. Eliason, "Maximum Likelihood Estimation," Series in Quantitative Application in the Social Sciences, Sage University Papers, 1996, Nico Nagelkerke, "Maximum Likelihood Estimation of functional relationships," Springer Verlag, January 1992, Press, W. H.; Flannery, B. P.; Teukolsky, S. A.; and Vetterling, W. T. "Robust Estimation." §15.7 in Numerical Recipes in FORTRAN: The Art of Scientific Computing, 2nd ed. Cambridge, England: Cambridge University Press, pp. 694-700, 1992.

Formally, an estimation technique which is insensitive to small departures from the idealized assumptions which have been used to optimize the technique. Also see any of the following patents, 6,374,216 Penalized maximum likelihood estimation

methods, the baum welch algorithm and diagonal balancing of symmetric matrices for the training of acoustic models in speech recognition, 6,097,776 Maximum likelihood estimation of symbol offset, 5,604,724 Maximum likelihood estimation using reference and spontaneous output peaks of partial response equalizer, 5,355,431 Text Signal detection apparatus including maximum likelihood estimation and noise suppression, 5,296,861 Method and apparatus for maximum likelihood estimation direct integer search in differential carrier phase attitude determination systems, 4,959,715 Method and apparatus for converting an interlaced television transmission to a sequential display using maximum likelihood estimation, 4,684,955 Maximum likelihood estimation of G/T of satellite earth terminals using extraterrestrial radio sources, 4,422,165 Maximum likelihood estimation of the ratio of the velocities of compressional and shear waves.

Applicant takes note that maximum likelihood estimation is well known to those of ordinary skill in the art. Certainly, there is no need for the Applicant to explain well known mathematical principles that date back centuries.

The invention projects in turn, for each one of a plurality of projectors, a single registration image onto a display surface. A union of the single registration images forms a polygon. An input image is acquired in turn, for each registration image by a camera. A single projective matrix is determined between the display area and each input image for each projector.

In other words, the projective matrix is determined entirely and *directly* only from the single projected registration images and nothing else.

Source images for each projector are warped according to the single projective matrices, and pixels of the warped source images are weighted according to the single projective matrix. The warped and weighted source images are then projected concurrently and directly onto the display surface to form a mosaic image.

The warping according to the invention is performed using a homography that is determined during a single calibration step using a single registration image.

It should be noted that the single projective matrix as claimed is a homography. As formally defined in the art, a homography is a parametric function that maps pixels in a first image to pixels in another image. The homograph can be expressed functionally as (x,y) = H(u,v), where the function H is in the form of a 3x3 matrix. As an advantage, any pixel location can be mapped simply by applying the function H. A homography does not require a table look-up, nor interpolation. For further details on the formal requirements for a homography see U.S. Patent No. 5,598,515 issued to Shashua on January 28, 1997, and U. S. Patent No. 6,527,395 issued to Raskar et al. on March 4, 2003

The Examiner rejects claims 1-7, and 11 under 36 U.S.C. 102(b) as being anticipated by Surati (U.S. 6,456,339).

In contrast to the invention, Surati uses a two step indirect calibration process with **two** test charts, see Figures 6 and 7 and the corresponding text in the specification.

To establish a screen to camera mapping (SC) a first test chart (43) is placed on the screen and an image is taken of the test chart, see Figure 7.

To establish a projector to camera mapping (PC) a second test chart (71) is projected on the screen and an image is taken of the second test chart, see Figure 8.

The two calibration images are than used to establish a *non-parametric* mapping between the projector and the screen that is used to warp images, see Figure 3 and 4A.

The *non-parametric* mapping of Surati uses a 2D look-up table (315), see column 11, lines 15-20, "The outcome of the calibration phase 301 is a ***two-dimensional lookup table*** 315. During the display phase 303, *the lookup table* 315 is used by an image warper 317 to warp an image 319 to be displayed." Also see the look-up mapping in Figures 11A-11C.

One of ordinary skill in the art would not confuse the discrete look-up table of Surati with the continuous functional projective matrix as claimed.

Obviously, as a disadvantage, a look-up table requires interpolation for discrete pixels that are not in the table, see column 16, lines 56-67.

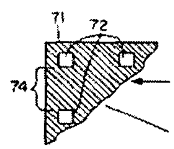
As an advantage, the parametric projective matrix according to the invention is continuous over all pixels.

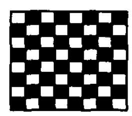
In short, Surati is distinguished and inferior in two counts. One, the calibration is a two step process requiring two test charts and two images per projector, and the mapping used for warping is discrete and non-parametric.

The claimed method uses a single calibration step with a single registration image, and the warping is done is parametric according to a projective matrix in the form of a homography.

Claims 2-4 deal with a display surface that is oblique to an optical axis of the projectors. Column 8, lines 26-38 make no reference to: an oblique angle, nor an optical axis.

The test chart 71 in Surati is not a checkerboard pattern. One of ordinary skill in the art would not recognize the test chart on the left below with a checkerboard shown on the right. There are no black squares in the test chart. There is not an equal number of alternating black and white squares. There is space between the squares.





Moreover the features 72 are *landmarks* that need to be carefully spaced. "The space 74 between landmarks presents an additional concern. A large space between landmarks tends to reduce the effect light from adjacent landmarks has on a particular landmarks' measurement. On the other hand, a small space between landmarks tends to reduce the number of required test chart pictures by having as many landmarks as possible on one screen. In experiments, the landmarks are separated by 30 pixels, eliminating the measurable effect from adjacent landmarks, yet limiting the total number of required test screen pictures to sixteen per projector," column 13, line 11 et seq.

Landmarks are precluded in checkerboards.

Surati describe a display area that is a largest rectangle enclosed by a polygon. Figure 1 does show a single rectangle. Nowhere does Surati describe homographies. His relationships are table look-ups.

All rejections have been complied with, and applicant respectfully submits that the application is now in condition for allowance. The applicant urges the Examiner to contact the applicant's attorney at phone and address indicated below if assistance is required to move the present application to allowance. Please charge any shortages in fees in connection with this filing to Deposit Account 50-0749.

Respectfully submitted,
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Specification

Please amend the abstract as follows.

Abstract of the Disclosure

A method forms a mosaic image on a display surface with a multiple projectors. For each projector in turn, a registration image is projected onto the display surface so that a union of the projected registration images forms a polygon. With a camera, for each registration image in turn, a corresponding input image is acquired. A display area on the display surface enclosed by the polygon is then identified, and a single projective matrix between the display area and each input image is determined for each projector. A source image for each projector is warped according to the corresponding homography of the projector. The pixels of the warped source image are weighted according to the single projective matrix, and then the warped and weighted source images are ~~concurretnly~~ concurrently projected directly onto the display surface to form the mosaic image.